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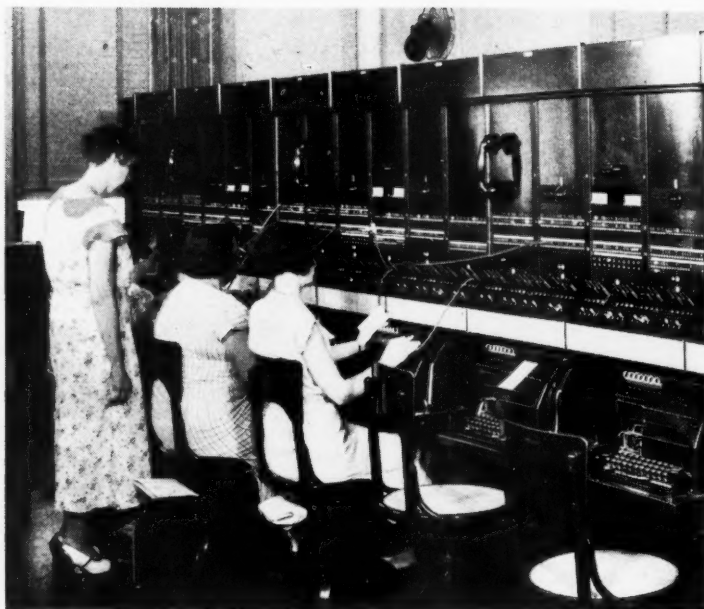
Test Plantation for Telephone Poles at Chester, New Jersey

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Novel Design Adapts 3A TWX to Wide Range of Conditions

By A. D. KNOWLTON

Equipment Development

EXPERIENCE with the manual telephone switchboard over a period of many years has built up a technique which has been invaluable in the development of switchboards for the nation-wide teletypewriter exchange service.* In the early stages of a new art, however, the expansion of service and the development of new and improved circuits cause fluctuations in factors that in an established art are normally stable. Because of this, it soon became evident that it would be sound economic policy to design the switchboards so that they could be readily adjusted to these changing conditions without major alterations. This, together with the problem of incorporating the tele-

typewriter in a keyshelf design that would allow efficient use of the multiple, constituted the two major problems in the design of the new No. 3A teletypewriter switchboard for the medium-sized switching areas.

Fundamentally, a manual switchboard consists of a number of subscriber and interoffice lines terminated in multiple jacks before which are placed operators, each having access to all lines, and each furnished with a number of cords for making connections between the lines. The expense of this multiple is an important factor in the initial cost of the switchboard, and it is therefore important that the operators be placed on as close centers as possible up to the point where the operators become crowded, so as to

*RECORD, Jan., 1932, p. 145.

reduce to a minimum the total length of multiple required for a given number of operators.

It soon became evident that if the teletypewriter were placed at the same level as the cords, the width of the position would greatly exceed the minimum width which past experience had shown to be approximately 22 inches, because additional space along the length of the board would be required for cords and keys to make up for the space occupied by the teletypewriter. Furthermore, with the teletypewriter fixed in the keyshelf, a predetermined number of cords would have to be provided in the original design. Since the number of cords required per operator is determined by the average holding time and the features of the circuits—factors which are in a state of flux in a new art—any future change in these factors would decrease the efficiency of the use of the multiple.

To reduce the width of the position, and at the same time permit the teletypewriter to be associated with any number of cords with little change, the plan was evolved of locating the cord equipment above the teletypewriter and putting the teletypewriter on a separate table, which could be placed anywhere in front of the switchboard. If it were placed in front of a standard keyshelf, the operator would be too far from the multiple for convenient reaching, and so a sloping keyshelf, shown in cross-section in Figure 3, was developed. To keep the sloping section as short as possible, the cords were placed in a single row, instead of putting the calling cords in one row and the answering cords in another as is usually done. The calling and answering end of each cord pair are adjacent, and are differentiated by using a red shell on the calling

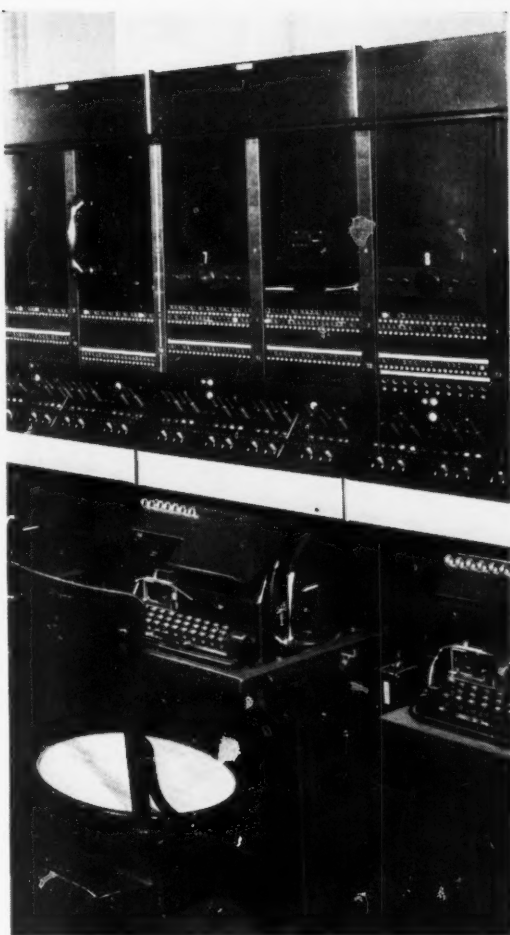


Fig. 1—Handsets are provided on the front of the board for communication with points within the office

plug and a black shell on the other.

The arrangement adopted was the result of experimentation with different models to determine the best design. In this investigation such factors as the ease of handling cords and keys, the sliding action of the cord in returning to the keyshelf, and the efficient location of the teletypewriter with respect to the multiple played important parts. The locating of the cords above the teletypewriter made possible the use of a standard length cord while permitting a 26½-inch instead of a 40-inch operating height for

the teletypewriter. This permitted the operators' chairs to be set directly on the floor and eliminated the necessity of a foot rail. With the standard length cord the usual amount of relay equipment could be located in the rear of the section, since the space available is limited ordinarily by the height of the cordshelf.

The depth of the teletypewriter makes it necessary that the back be placed approximately five inches behind the face of the jacks to permit the operator to sit close enough to the jack field for the most efficient operation. The sloping keyshelf provided an arrangement whereby this could be done, the cords passing the teletypewriter over a stainless steel bar.

Each section of switchboard carries two 10 $\frac{1}{4}$ -inch panels of multiple, and three sections are required for the maximum of 1200 lines for which the board is designed. This gives an overall width of 63 inches for the complete multiple, which is well within an

operator's reach. The number of operators required is affected not only by the number of lines, but by the average holding time and the average frequency of calls per line. Since with a new type of service any of these factors may change from time to time, every effort was made to obtain flexibility in the grouping of cords with operators and in varying the number of operating positions. Economic considerations, moreover, make it desirable to supply no more equipment in the way of cord circuits for the switchboard than is immediately needed under existing conditions.

The desired flexibility was secured by an arrangement indicated diagrammatically in Figure 2. The cords and keys are wired to terminal strips, and the cord relay equipment is mounted on units also equipped with terminal strips. These units, which accommodate equipment for ten cord circuits, are mounted in the rear of the switchboard immediately below

the terminal strips for the cords, and distributing rings are provided so that any relay equipment can be cross-connected to any cord in the keyshelf, either in the same or in a different section. Each section is provided with a position circuit which is wired to terminal strips and to a multi-contact jack below the front panel of the switchboard where it may be connected to a teletypewriter.

Such an arrangement secures a maximum of flexibility. A sufficient number of

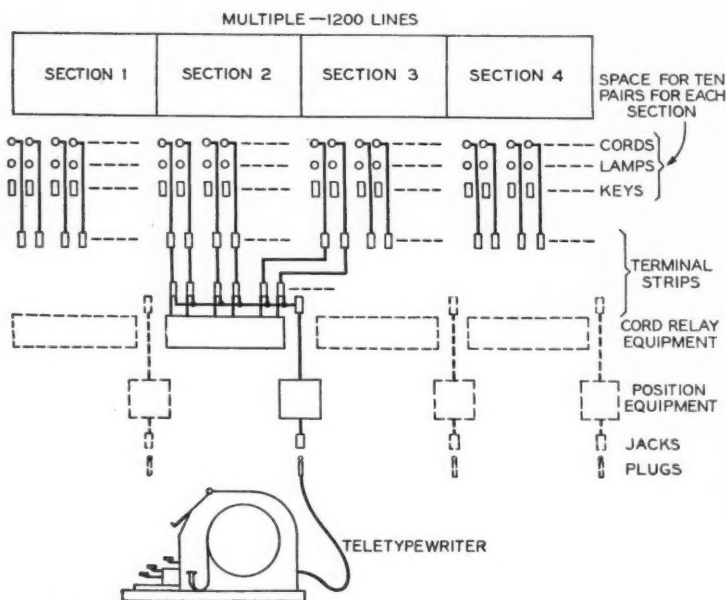


Fig. 2—Schematic of circuit arrangement, showing flexibility obtained by the use of terminal strips and cross-connections

sections will be installed originally to accommodate the maximum number of positions that is likely to be needed, but sufficient equipment is installed only for the number of positions and cords needed at the moment. The flexible cross-connection provisions permit the number of cords per operator or the number of positions to be readily changed at any time. No matter how many sections of board are installed, only sufficient relay units need be installed to serve the required number of cords, and the cords employed may be selected from any place along the keyshelf. Each multiple jack has a line lamp associated with it so that incoming calls are indicated at each appearance. This allows any operator to answer any call rather than restricting her to serve a predetermined group of lines.

With such a design, the engineering of various installations is reduced to a very simple process. The number of cords required per operator is determined by the anticipated traffic data. From this information the width of each position is determined. The sum of the positions required to handle the peak load represents the total length of the switchboard and determines the total number of sections required. Cord units are then supplied in the rear of the switchboard to provide for the total number of cords to be equipped. The cords required for each position are then cross-connected to the nearest position circuit. Teletype-

writers are moved in front of the various groups of cords and plugged into the jacks for their position circuits. The positions are then ready for

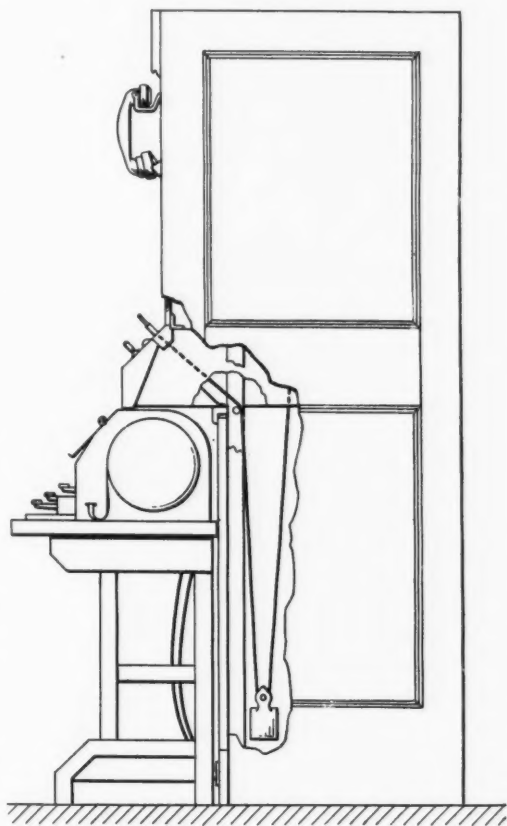
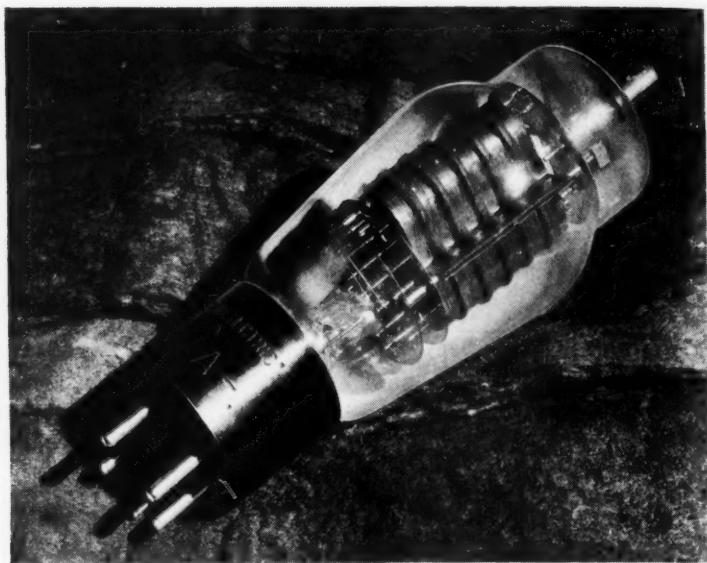


Fig. 3—Cross-section view of the 3A teletypewriter switchboard

operation. Should conditions require a different assignment of cords, the cross-connections may be changed to meet the new requirements, and the teletypewriters moved to new positions along the switchboard.



The 307A Power Pentode

By E. A. VEAZIE

Vacuum Tube Development

IN the early design of radio-frequency amplifiers the inherent limitations of the three-element vacuum tube introduced many complexities. If reasonable gains were expected, neutralization was necessary to prevent feedback from the output to the input circuit, and the maximum theoretical gain could never be reached because of the losses due to this neutralization. To modulate the output stage of such an amplifier an audio-frequency power level comparable with the radio-frequency power output was required.

As the tube art progressed, four-element tubes were developed in which the outermost grid served as an electrostatic shield between the plate and the control grid. The capacitance between the plate and the control grid was sufficiently reduced by this means to eliminate the need for neutralization. These four-element "screen grid"

tubes found wide use as voltage amplifiers at radio frequencies but new difficulties appeared caused by the emission of secondary electrons from both plate and screen grid. If the instantaneous plate voltage dropped below the screen voltage as the plate potential varied, secondary electrons knocked from the plate traveled to the screen. It was therefore necessary to limit the instantaneous plate voltage to values greater than the screen potential to avoid excessive distortion of the signal and the consequent limitation of plate efficiency. Secondary electrons emitted by the screen grid were also a continuous source of trouble, and placed serious limitations on the circuit supplying the screen voltage.

A third grid was added to the screen-grid tube to overcome these limitations, thus producing the pentode. This grid was located between

the screen grid and the plate and was originally tied to the cathode within the tube. Its sole function was to prevent the flow of secondary electrons in either direction. Hence it was appropriately called a suppressor grid.

This development satisfactorily overcame the disadvantages of the screen-grid tube while retaining the advantages. These pentodes are characterized by a comparatively high power output at a low plate voltage, and a high gain per stage—thereby effecting economies in plate-voltage supply equipment and in radio-frequency driving power. These two items of themselves would result in a widespread use of this form of tube. On closer examination it is seen that there are still further possibilities contained in this three-grid structure.

If the suppressor grid be disconnected from the cathode, and the radio-frequency output current of the tube be examined as a function of voltages applied to this grid, it will be seen that there is a possibility of using the suppressor for the purposes of modulation. The Western Electric 307A tube, intended for use in mobile transmitters, has been designed to take full advantage of this possibility. Basically this tube is a suppressor grid pentode, but separate leads are provided for each of the three grids, thus permitting the application of any desired voltages to each.

The innermost of these grids, through control of the rate at which electrons leave the cathode, performs functions similar to those of the grid of a triode. The second, or screen grid, is maintained at a fairly high positive potential, and provides the principal accelerating force tending to draw electrons out from the cathode. Because of its open structure, however, practically all the electrons pass

through this grid into the space beyond. The suppressor grid plays only a small part in controlling the number of electrons drawn from the cathode, but its potential determines the way in which the total current divides between the screen grid and the plate. When its potential is zero, practically all electrons passing through the screen have sufficient velocity to overcome the retarding effect of the suppressor and continue on to the plate. As the suppressor is carried more and more negative, the fraction of the electrons turned back increases, and consequently the plate current decreases. In fact it is possible to reduce the plate current essentially to zero by making the suppressor grid sufficiently negative.

Characteristic curves for the 307A tube are shown in Figures 1 and 2. In Figure 1 the plate current is shown as a function of the plate voltage for several values of control-grid voltage,

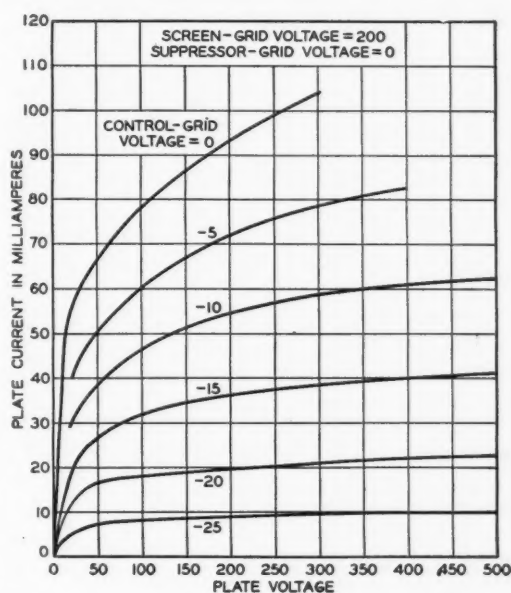


Fig. 1—Static characteristics of 307A tube showing plate current as a function of plate potential—screen-grid potential two hundred volts and suppressor-grid potential zero

the potential of the screen-grid and suppressor-grid being held fixed. The smoothness of these curves in the region where the plate voltage approximately equals the screen-grid voltage indicates the complete effectiveness of the suppressor grid in preventing flow of secondary electrons. The curves of Figure 2 show the plate current as a function of control-grid voltage for several suppressor-grid voltages with plate and screen potentials constant. These curves indicate the parts played by the control and suppressor grids in controlling the current to the plate.

When the tube is used as a modulating amplifier, a radio-frequency input is applied to the control grid. This results in corresponding radio-frequency

variations in the plate current. The amplitude of these variations in current and the magnitude of the plate circuit load determine the high-frequency power output of the tube. Under these conditions the amplitude of the current variations is reduced as the voltage on the suppressor grid is made more negative. Thus the high-frequency output power of the tube depends directly on the potential of the suppressor grid.

It is this dependence of the high-frequency output on the suppressor potential that makes it possible to use the tube as a modulator. In an ideal amplitude modulator, the high-frequency current in the load is a linear function of the modulating potential. In the pentode this requires careful mechanical design of the grid structures. How close the 307A tube comes to meeting the ideal can well be judged from the curve in Figure 3 which shows the dynamic characteristics for a plate potential of 500 volts.

For radio telephone use, under the conditions for Figure 3, the suppressor might suitably be biased at minus 50 volts. A swing of plus and minus 50 volts from this value causes variation of the load current from approximately double the normal value to practically zero. It is unnecessary to provide a low-frequency power amplifier between the microphone and the modulator tube because a peak voltage of about this amplitude can be obtained directly from a handset with a suitable transformer.

The greatest advantage of the 307A tube over other types lies in the fact that the output may be modulated almost completely by varying the potential of an element which, being continuously negative with respect to the cathode, does not draw space current.

The 307A tube is also suitable for

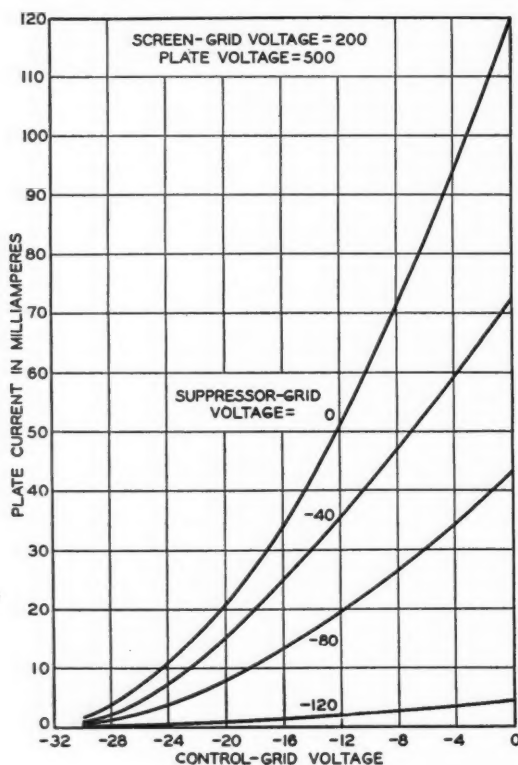


Fig. 2—Relation between plate current and control grid potential of the 307A tube for a plate potential of five hundred volts and a screen-grid potential of two hundred volts

use as an oscillator. A complete transmitter may be built around two such tubes, with one providing the high-frequency power necessary for driving, and the other serving as a modulator. The relative simplicity of such a circuit, with a minimum number of tubes and associated circuit elements, makes it particularly adapted to transmitters for aircraft, where both small size and light weight are factors of major importance.

The use of a filamentary type of cathode in the 307A tube, rather than an indirectly heated cathode, makes possible important operating economies. Because the cathode used requires only a very few seconds to reach operating temperature, the transmitter may be completely shut down when not in use, but is almost instantly available when needed. Similar transmitter performance could be obtained with equipo-

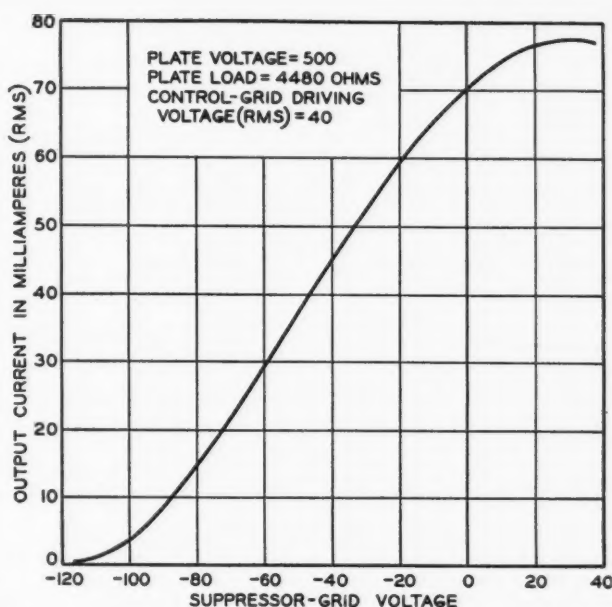
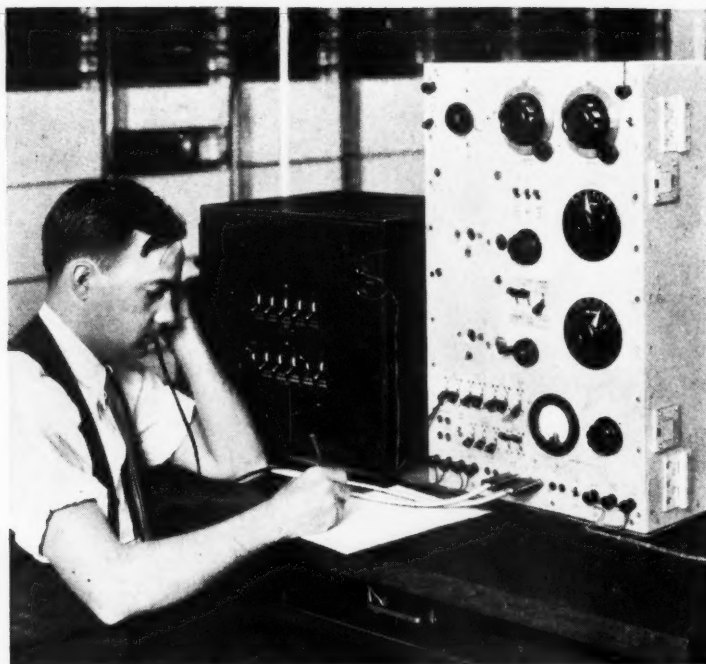


Fig. 3—Dynamic characteristics of 307A tube for a plate potential of 500 volts

tential cathode tubes only by maintaining the cathode at close to normal operating temperature during idle periods. Both supply power and useful tube life are thus conserved by use of the filamentary cathode.

Another installation of harbor-craft radio telephone service has recently been made in the Philadelphia area. This system, which went into operation early last autumn, is operated by the Atlantic Communications Corporation. It is employed chiefly for dispatching tow boats—used in considerable numbers for transporting tankers to and from the refineries along the Schuylkill. It differs from other harbor-craft systems in employing an ultra-high frequency and in incorporating voice-control of the carrier.



Measuring Delay on Picture-Transmission Circuits

By E. P. FELCH

Telephone Apparatus Development

ELECTRIC impulses require a finite time for their transmission over any ordinary circuit, and the time interval from the instant a signal leaves the sending end to the instant it arrives at the receiving end is known as the delay of the circuit. This effect is illustrated by the oscillogram of Figure 1, where the upper graph shows a transmitted pulse of a single frequency, and the lower graph shows the same pulse as received. If the delay were the same for all frequencies, it would have no detrimental effect on transmission, but actually it varies with frequency. As a result some frequencies are delayed more than others. This results in a distortion of the received signal,

which is known as delay distortion.

During the development of transmission facilities for the new telephotograph system, it was found that stringent requirements for delay distortion would have to be met, and as a result that delay equalizers would have to be employed. The design of the necessary equalizers could not be carried out, however, until the delay characteristics of typical circuits had been accurately determined. Delay measurements are not new. They were made extensively with a laboratory set in connection with the early telephotography undertaken by the Bell System, and were also made over an 1800-mile stretch of experimental cable circuit arranged to meet the

higher standards of the new telephotograph system. It was evident, however, that for many of the measurements that had to be made, more refined apparatus would be required. A new measuring set was consequently developed which employed the arrangement described below. Modifications were also made in the older set, however, which greatly improved its accuracy, and it was used in the final lining-up of the new picture-transmission system, in measurements centering at New York City.

An obvious method of measuring delay would be to transmit a short pulse of constant frequency around a loop, and to record both sent and received signals on the same oscillograph record as in Figure 1. The time between the beginning of the transmitted and received pulses would be the delay. There are two reasons, however, why such a comparatively simple method is not suitable. In the first place it will be noted from Figure 1 that an appreciable time is required for the received signal to build up to its full value. Moreover, the correct time of arrival of the received wave is not the instant when the first disturbance is noted at the receiving end, and there is no way to determine from the graph just what is the correct

instant for the beginning of the received signal. Besides this difficulty, it is necessary to measure the delay to ten microseconds, while the oscillograms cannot be read to better than a thousandth of a second.

Distortionless transmission of electrical signals requires the preservation of the shape of the envelope of the signal impulses. This requirement is fulfilled when the "envelope delay," which is defined as the rate of change in phase shift with respect to frequency, is constant over the band of transmitted frequencies. In other words, if B is the phase shift at frequency F , and B' at some slightly higher frequency F' , then envelope delay is the value expressed by the quotient $(B'-B)/(F'-F)$ as the difference between F and F' approaches zero.

Practically, in measuring envelope delay, it is not necessary that the difference between F' and F be vanishingly small. Where the two frequencies are separated a finite amount, the quotient of $B'-B/F'-F$ will give the envelope delay for the average of the two frequencies very closely under ordinary conditions, and if the delay in seconds is proportional to the frequency, $B'-B/F'-F$ gives exactly the envelope delay for the average frequency. By taking advantage of this

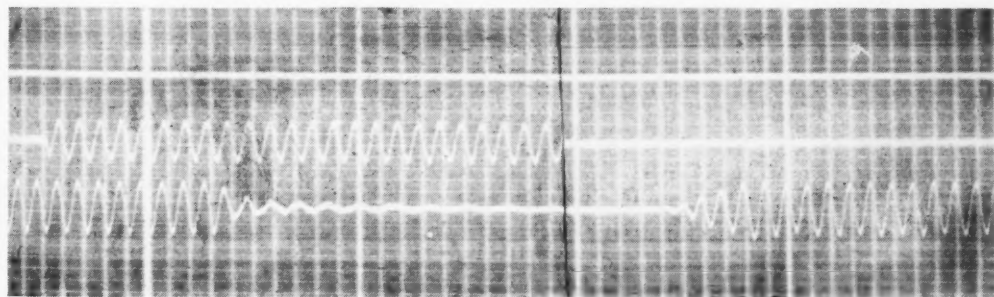


Fig. 1—A signal requires a definite time for its transmission over a circuit, and the time from its start at the sending end (shown in upper track) to its arrival at the receiving end (shown in lower track) is known as the delay of the circuit

relationship it is possible to obtain the delay characteristics of a circuit by measuring the difference in phase shift for two frequencies separated by a small but finite amount.

This could be done either by measuring a phase change for a fixed fre-

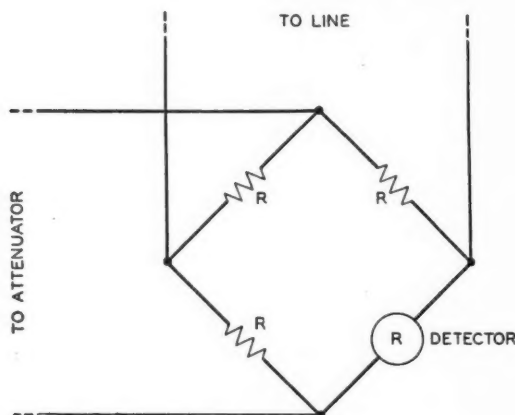


Fig. 2—A bridge circuit was employed to determine when the phase shift in the line amounted to an even number of cycles

quency interval, or by measuring the change in frequency required to produce a definite phase change. The first would require a fixed frequency source and accurate adjustable phase shifters, while the second would require a method of establishing fixed phase intervals, and an adjustable frequency source. The latter system was adopted because it would require only high-stability oscillators, which are comparatively easy to obtain. The phase shift was determined by employing a bridge circuit as shown in Figure 2. The output from an adjustable oscillator is divided, part passing over the line and part through an attenuator which produces no delay. This attenuator is adjusted to give a loss exactly equal to that of

the line. The line, however, in addition to the loss it produces, causes a phase shift, so that the currents at the two sides of the bridge are equal in magnitude but differ in phase. The frequency of the oscillator is then adjusted until the phase shift is an even number of cycles. Under these conditions the bridge will balance, and thus a zero reading on the indicator of the bridge shows that the phase shift for the frequency of the oscillator is an even number of cycles.

With this frequency determined, the frequency of the oscillator is gradually increased. The bridge at once goes out of balance and does not again become balanced until the phase shift has increased by one complete cycle. This second balance point gives another frequency, and the difference between these two frequencies, Δf , is the frequency change required to produce an increase in phase shift of one cycle.

The phase shift is known accurately because of the high precision with which the balance position of the bridge can be determined. The frequency is measured by combining the two frequencies on a single oscillograph string and measuring the dur-

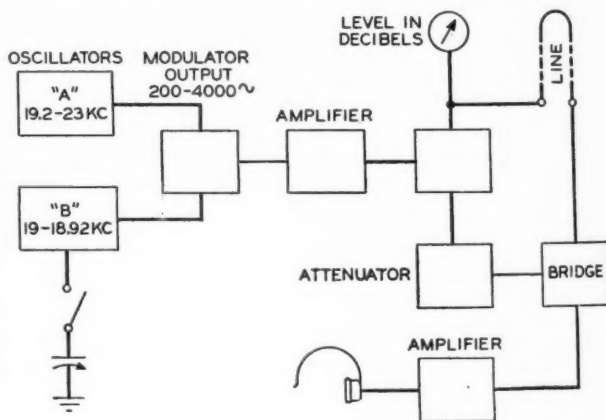


Fig. 3—Simplified schematic of apparatus which is used for measuring envelope delay

ation of the beat-frequency cycle by comparison with hundred-cycle timing lines obtained from an auxiliary frequency standard. By this method ΔF can be determined to about a thousandth of a cycle. The delay measurements were required to about ten microseconds, and a rough calculation showed that to obtain this precision ΔF would have to be about fifty cycles, which corresponds to a delay of about five cycles. For convenience in these measurements, the unit of delay was taken as half-cycles, which were called π -points, since a half cycle corresponds to π radians.

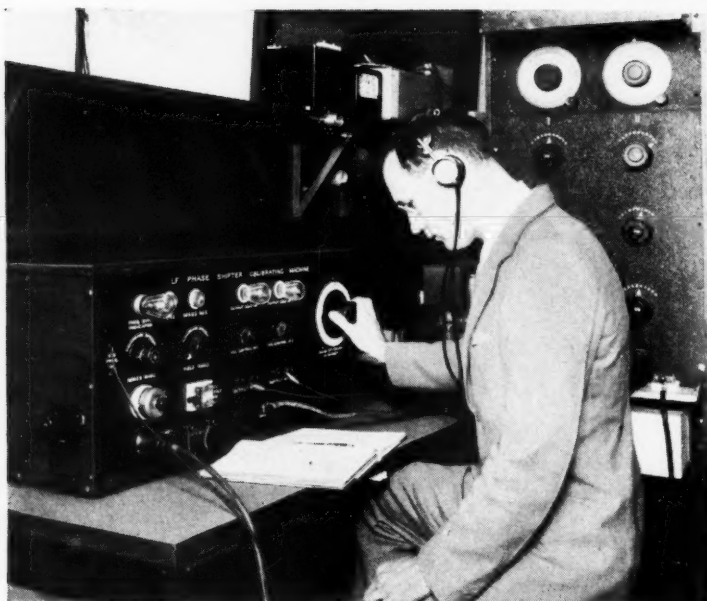
As finally used for measurements, the apparatus was as indicated in Figure 3. Oscillator A determines the frequency at which the particular delay measurement is to be made, while oscillator B gives the frequency interval for which the change in phase shift is to be measured. The outputs of these two oscillators are combined in the modulator, making possible output frequencies from two hundred to four thousand cycles, which more than cover the band width required for telephotography. The rest of the circuit, employed for obtaining a definite value of difference in phase shift, is essentially like that of Figure 2. Oscillator B has associated with it an accurately calibrated air condenser which allows its frequency to be known from the condenser setting.

To illustrate the method of operation, it may be assumed that delay is to be measured at 1200 cycles. Oscillator A might be set to 20.1 kc. and oscillator B to 18.9. The bridge would probably not be in balance at these settings but a slight adjustment of

oscillator A would bring it into balance. After this, the frequency of A would be slowly increased until the next balance point was reached. The difference between these two frequencies would give the ΔF for a difference in phase shift of two π -points. Having determined this value, the condenser of oscillator B is set for an increase of about fifty cycles and then adjusted over a small range to secure another balance point on the bridge. This gives two frequencies causing a difference in phase shift of a whole number of π -points. The actual number of π -points is found by dividing twice the difference between the two frequencies, $F_2 - F_1$, by ΔF determined previously, and this number of π -points divided by $2(F_2 - F_1)$ gives the envelope delay of a frequency half way between F_2 and F_1 .

With such an arrangement readings may be made very rapidly. The work was facilitated by preparing graphs from which the envelope delay could be read directly for a given number of π -points and frequency differences. The apparatus as finally arranged is shown at the right in the photograph at the head of this article. Since the completion of the development tests, the experimental model has been turned over to the Long Lines Department for tests on the system.

Except for very short circuits most of the measurements were made at night because of the rapid fluctuations encountered during the daylight hours due to the effects of temperature on phase angle. Stability was usually obtained about midnight, and from then until daybreak measurements were made continuously.



An Adjustable Precision Standard of Phase Difference

By G. B. ENGELHARDT
Carrier Transmission Research

MEASUREMENTS of phase shift are of major importance in the development of communication systems. In general, any network or piece of apparatus inserted in a circuit produces a phase shift, and it is becoming increasingly important in many recent developments to know its magnitude. A variety of methods are used for making such measurements. These frequently employ calibrated phase shifters operating at a fixed low frequency. For calibrating these phase shifters in the carrier research laboratory, an adjustable standard of phase difference has recently been built. While maintaining a high degree of precision, this standard is simple in construction and quick in operation. The photograph at the head of this article

shows the standard being used to calibrate the two 400-cycle phase shifters, shown at the top of the relay rack on the right.

In brief, the apparatus provides two voltages of equal frequency and amplitude which may be given any desired phase difference by shifting the phase of one of the sources. A simplified schematic of the calibrating circuit is shown in Figure 1. The adjustable source is first set to equal level and phase opposition with the reference source as judged by a null indication on the detector. The phase shifting device to be calibrated is then inserted in the circuit of the reference source and adjusted until a null reading is again obtained on the detector. An accompanying change in the setting of the resistance attenuators will

generally be required to compensate for the loss of the phase shifting device. This gives the setting of the phase shifting device under test for zero phase shift. Other points may be determined by setting the device to be calibrated to produce varying degrees of phase shift and changing the adjustable source to produce a null reading. The reading of the dial then gives the phase shift of the device.

The constant-frequency sources are two similar alternating-current generators having rigidly coupled rotors. They are mounted behind the front panel of the set as shown at the left in Figure 2. These machines also have d-c. windings which furnish their driving power, and rheostats on the front of the panel—at the right of Figure 2—permit the speed to be set to any desired value. The stator of one of the alternators is rigidly fastened to the base, but that of the other is mounted on ball bearings, so that by means of a worm drive—at the extreme left of Figure 2—it may be rotated around its axis with respect to the fixed stator. Backlash is prevented by a weight attached to the movable stator which preloads the

gears in one direction. The slow-speed shaft of the worm drive connects to a large knob and dial on the front of the panel.

The machine utilizes the two-alternator method of obtaining known phase shift. Because of the linear relationship existing between electrical degrees of phase shift of the output

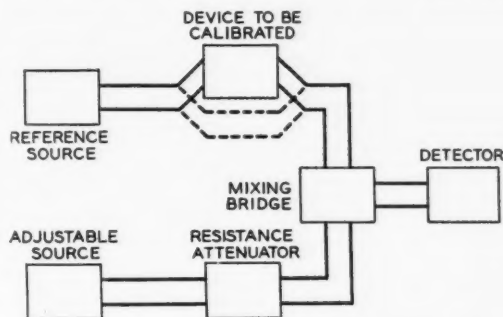


Fig. 1—Simplified schematic of phase shift calibrating circuit

and the mechanical degrees of rotation of the stator, the dial may be etched with a linear scale reading directly the electrical phase difference between the output of the two machines. This relationship holds true accurately regardless of irregularities in the machines such as uneven flux distribution or unequally placed slots.

The effect of such inequalities is only to introduce other frequencies in the output, but the desired frequency is always present, and all of the other frequencies are eliminated by the use of filters.

The speed of the alternators may be adjusted to give any frequency from fifty to one thousand cycles per second. The frequency is continuously compared with a stand-

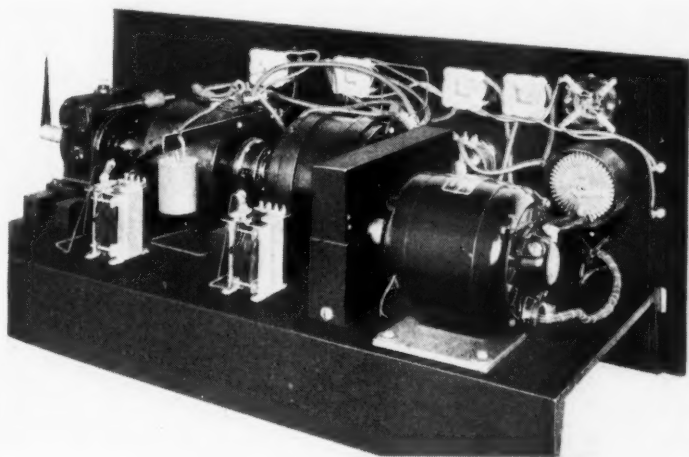


Fig. 2—Rear view of calibrating apparatus

ard frequency of the desired value by a neon tube. This tube is connected between the standard frequency source and the output of one of the alternators. If the frequency of the alternator differs from that of the standard, the phase of the two sources will alternately aid and oppose, causing the lamp to flash on and off. A flashing lamp, therefore, indicates a difference in frequency between the generators and the standard, while a steady lamp which is either lighted or

City is held within very close frequency limits, this gives a fairly accurate output of four hundred cycles. If a frequency other than four hundred cycles is desired, the synchronous motor is disconnected and the alternators are driven at the desired speed by their self-contained direct-current windings.

While the upper frequency of the generators is one thousand cycles, the set may be employed for calibrations at higher frequencies by heterodyning

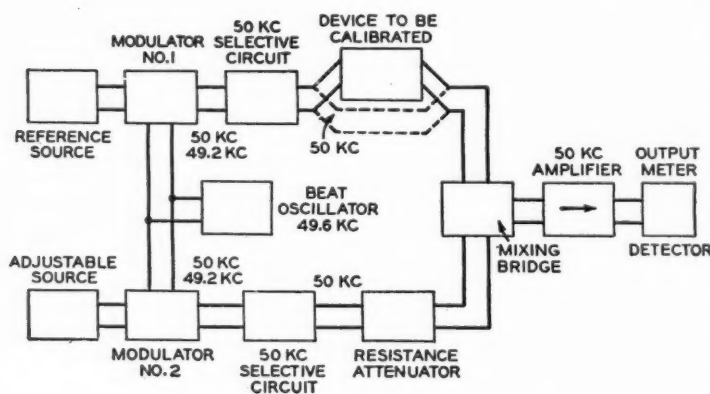


Fig. 3—Circuit arrangement for measuring phase shift at fifty kilocycles

out indicates equality of frequency.

Since four hundred cycles per second is commonly used for calibrating in the carrier research laboratory, provision has been made for procuring high stability at this frequency. This is accomplished by employing a small synchronous motor, which maintains the generators at such a speed that the output is four hundred cycles if the power supply is sixty cycles. Inasmuch as the a-c. supply in New York

the outputs of the two generators with a common beat oscillator. Such an arrangement for calibrating at fifty kilocycles is shown in Figure 3. Under these conditions, the synchronous motor is used, and thus the output of the two alternators is at four hundred cycles. The common beat oscillator has a frequency of 49.6 kc., which gives a fifty-kc. frequency for

the upper sideband; other modulation products are eliminated in the selective circuits, which may either be inserted in the separate branches as shown, or included in the common branch following the mixing bridge. A resistance attenuator, which has a known phase shift at the test frequency, is employed to equalize the amplitude of the outputs at the mixing bridge before the final adjustment for phase shift is made.

News of the Month

INCREASED ENROLLMENT IN OUT-OF-HOUR COURSES

THERE WAS a decided increase in the enrollment for out-of-hour courses this fall—a registration of 834 for all courses as compared with 675 last autumn. This increase took place in the classroom courses rather than in the lecture series. There were 564 registrations in the former against 411 in 1934, whereas there were about 270 in the lecture series both years. The registration by courses follows:

Classroom Courses	Registrations
Review of Calculus.....	75
Materials of Design.....	51
Dynamics of the Vacuum Tube.....	45
Electromagnetic Theory and Its Applications..	38
Feedback Amplifiers.....	129
Organization and Functioning of Bell System..	118
Mechanical Drafting.....	20
Telephone Practice.....	51
Speed Dictation.....	37

Lecture Series	
Transmission Development.....	152
Facilities Engineering.....	118

COLLOQUIUM

AT THE NOVEMBER 18 meeting of the Colloquium J. R. Dunning of Columbia University spoke on *Interaction of Slow Neutrons with Matter*. "Fast" neutrons are characterized almost entirely by elastic collisions with atomic nuclei. "Slow" neutrons show as much as thirty thousand times increased interaction with nuclei, and produce various types of nuclear transmutations often with considerable energy release, and with high efficiency. Mr. Dunning described a number of methods which have been used to study the properties of these slow neutrons. A mechanical velocity selector has been devised to determine their velocity distribution, and to form a spectrum for the purpose of carrying on further investigations.

P. D. Foote of the Gulf Research and Development Corporation spoke at the December 2 meeting on *Research in the Petroleum Industry*. He discussed geophysics, geology, physics, engineering, materials engineering and chemistry as applied to the petroleum industry and described the general type of work which concerns the Research Department of a large, completely integrated oil company in the discovery of oil fields, production, transportation, refining and marketing.

NEWS NOTES

F. B. JEWETT attended a meeting of the Policy Committee of the National Research Council held in New York on November 14.

DR. JEWETT, A. B. CLARK and E. I. GREEN were in Washington for the hearing before the Federal Communications Commission on November 25 concerning the coaxial cable installation between New York and Philadelphia.

NEW YORK UNIVERSITY recently conferred the degree of B.S. in Electrical Engineering on F. P. Balacek and C. E. Luffman of the Inspection Engineering Department, on J. Grammels of the Apparatus Development Department and on R. V. Crawford of the Systems Development Department.

A. F. PRICE and F. A. COLES visited Hawthorne to inspect the equipment for a naval announcing system.

H. C. CURL, at Newport News, discussed plans for a naval announcing system with the Newport News Shipbuilding and Drydock Company. Mr. Curl recently returned from an extended trip to the fleet for the purpose of general engineering studies.

A. F. PRICE and H. C. CURL discussed general problems relating to announcing systems with Navy officials at Washington.

F. B. WOODWORTH spoke on *Harbor-craft Radio Telephone System of the Atlantic Communications Company* before the Philadelphia section of The Institute of Radio Engineers on December 5.

FINAL TESTS were made by J. C. Herber and L. G. Young on the 306B (50-kilowatt) radio transmitting equipment for Station WJR.

THE INSTALLATIONS of D-96847 (5-kilowatt) radio transmitting equipments at Station WJAX of the City of Jacksonville, Station WOW of the Woodmen of the World Life Insurance Association of Omaha and Station WJAS of the Pittsburgh Radio Supply House were supervised by F. H. McIntosh, O. W. Towner and N. C. Olmstead, respectively.

W. L. BLACK visited Detroit on matters pertaining to new studio speech input equipment for Station WWJ of the Detroit News.

J. E. TARR supervised the installation of speech input equipment for the Teleflash Sports News at Boston.

R. E. KUEBLER was at Cleveland, Cincinnati, Buffalo, Pittsburgh, Baltimore and Newark in connection with speech input equipment for Teleflash Sports News.

A. A. SKENE visited Station WBBM, Chicago, and Station KFAB, Lincoln,

Nebraska, to inspect the synchronizing equipment used to permit the common frequency operation of these two stations. A study of the effects of common frequency operation upon radio reception at intermediate points between the stations was also made in conjunction with the station engineers.

RADIO APPARATUS was discussed by E. A. Bescherer, W. A. Woods and C. L. Van Inwagen with engineers of the U. S. Navy at Washington.

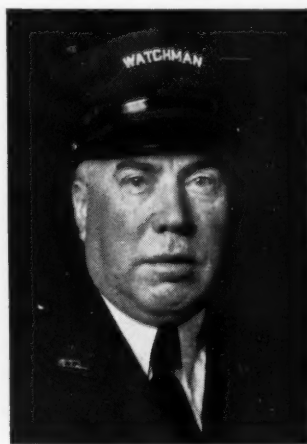
F. C. WARD was in Philadelphia in connection with the ultra-high-frequency harbor-craft system recently installed there for the Atlantic Communications Corporation.

RADIO PROJECTS were discussed by D. B. McKey, J. G. Nordahl and J. W. Smith with the Bureau of Engineering of the U. S. Navy at Washington.

THE LABORATORIES Ford Airplane used in the development of aircraft radio equipment is back in service after the periodic overhaul of its three Wasp motors at the Pratt and Whitney aircraft plant in Hartford. This is the fourth complete overhaul of these motors which have propelled this plane in slightly more than a thousand flights. The work of overhaul was under the direction of Captain A. R. Brooks, and under the direct super-



L. B. STARK
on November 13 completed thirty years of service in the Bell System



WILLIAM CARROLL
on December 11 completed thirty-five years of service in the Bell System



RAYMOND CALAME
on November 4 completed twenty-five years of service in the Bell System

vision of R. J. Zilch, the Laboratories airplane mechanic, who remained at the factory throughout the overhauling. Since 1928 the Laboratories planes have flown approximately 224,000 miles in over 2,100 flights and have carried approximately 4,550 persons and 1,320,000 pounds of "pay load" consisting of radio apparatus and associated equipment.

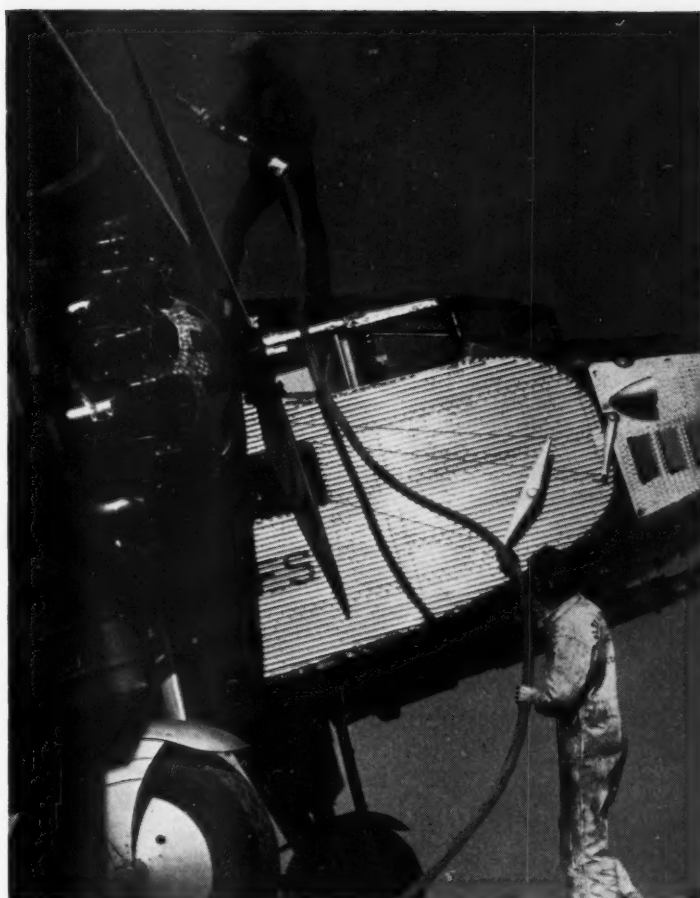
W. A. BISCHOFF visited Hawthorne to discuss standards in drafting practices.

D. T. MAY and E. MONTCHYK visited a central office in Brooklyn in connection with studies of the maintenance of panel system contacts.

E. L. FISHER and L. S. INSKIP, at various suburban points in New Jersey, observed field trials of special pole-mounted protectors which are being conducted on the lines of the New Jersey Bell Telephone Company.

C. H. WHEELER and G. H. DOWNES visited the Southern Bell Telephone Company at Atlanta and the Michigan Bell Telephone Company at Detroit to inspect trial installations of modified universal type keys.

F. F. LUCAS lectured before the Raritan Photographic Society at New Brunswick on *Biological Microscopy and Photomicrography*. He also contributed a thesis *On the Resolving Powers of the Infinity Objectives of N. A. (Numerical Aperture) 1.40 and N. A. 1.60 Used with a Precision High Power Metallographic Apparatus at Sendai, Japan*, for publication in the Honda Memorial Volume. This volume is to commemorate the twenty-fifth anni-



R. J. Zilch and a Hadley Airport attendant servicing our "flying laboratory"

versary of Dr. Honda's service in the Imperial University of Japan, of which he has been the president for the last few years.

J. R. TOWNSEND lectured before the Civil Engineering Colloquium on Engineering Mechanics held at Columbia University on November 14. His subject was *The Relationship of Fatigue to the Mechanical and Metallurgical Properties of Metals*. He gave a similar talk before the Cleveland Chapter of the American Society for Metals on December 2. Early in November Mr. Townsend was also at Hawthorne to discuss special alloys with engineers of the Western Electric Company.

J. J. MARTIN spent three days visiting phenol fibre factories in Pennsylvania and

Delaware. Those visited were the Synthane Corporation at Oaks, Pennsylvania, the National Vulcanized Fibre Company plants at Kennett Square, Pennsylvania and Yorklyn, Delaware, and the Continental Diamond Fibre Company at Newark, Delaware.

F. A. KUNTZ and E. W. NILES with M. L. Svikhart of the Queensboro Works made a field inspection of experimental telephone booths in conjunction with Southern New England telephone engineers at New Haven.

* * * * *

THE SUDDEN DEATH of E. P. Broe, of the toll facilities group, on the nineteenth of December was a shock to his many friends in the Bell System. Mr. Broe graduated from Columbia University in 1917 with the degree of E.E. and immediately joined the Engineering Department of the American Telephone and Telegraph Company. A year later he left



E. P. Broe

to serve in the World War, being an ensign in the U. S. Naval Reserve responsible for the installation and operation of radio telephone and telegraph equipment in seaplanes at the Norfolk Navy Yards.

On his return to the American Company in January, 1920, Mr. Broe became connected with the Department of Development and Research and until 1926 was concerned with local central office

developments, among which were the use of key indicator equipment for the giving of service between manual and dial central offices and the development of straightforward trunking between local central offices. He then transferred to the toll central office development group, being particularly active in the development of toll-tandem switchboards and the combined inward, through and tandem switchboard now under trial in the Long Lines office at 32 Sixth Avenue. He also made many important investigations of improved switching methods and mechanisms. When the Department of Development and Research was merged with the Laboratories in 1934, Mr. Broe continued with the Toll Facilities Department, carrying on general toll development projects.

* * * * *

J. J. KUHN visited Hawthorne to discuss problems concerning station apparatus. While there, he visited the Illinois Bell Telephone Company in connection with improvements in No. 7 type coin collectors.

L. N. HAMPTON and A. K. SMITH visited the Philadelphia plant of the Jiffe Company in connection with development work on compressors used in the cleaning of central office equipment by high-pressure air.

PROBLEMS CONCERNING the new combined hand telephone set and other station apparatus were discussed by H. I. Beardsley during a three-week sojourn at Hawthorne. W. J. Thayer also visited Hawthorne in connection with the same project.

D. D. MILLER visited Hawthorne to discuss a new combination connecting block and jack assembly for terminating central office incoming circuits which are entirely in underground cable. He also discussed various manufacturing problems pertaining to relays.

H. A. BREDEHOFT discussed with Hawthorne engineers manufacturing problems in connection with the small ringer employed in the new combined hand telephone sets.

THE PROGRESS of carrier-frequency open-wire tests being conducted at Mount Pocono and Phoenixville was reviewed by A. B. Clark, H. A. Affel, R. G. McCurdy, A. G. Chapman, E. I. Green, R. N. Hunter and L. M. Ilgenfritz during a recent trip.

M. J. KELLY and W. C. JONES were in Hawthorne to confer with engineers of the Manufacturing Department.

MR. KELLY and HARVEY FLETCHER attended a meeting of the Advisory Council on Applied Physics of the American Institute of Physics that was held in Pittsburgh.

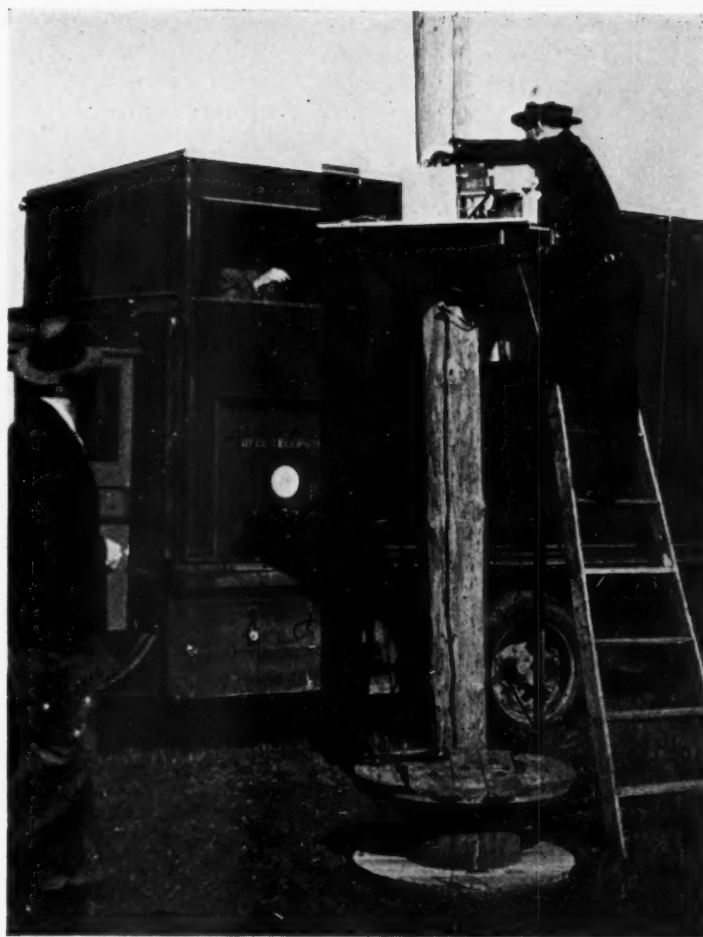
DR. FLETCHER spoke before the Engineers Club of Charlotte, North Carolina, on *Mechanism of Hearing and Its Relation to the Noise Problems*. He also attended a meeting of the National Academy of Sciences that was held at the University of Virginia, Charlottesville, Virginia.

F. S. MALM was in Cleveland in connection with a field trial installation of buried rubber-covered wire in the plant of the Ohio Bell Telephone Company.

THE PREPARATION of diaphragm materials for handsets was discussed by J. E. Harris, J. H. White and W. C. Jones at Hawthorne.

A. M. SKELLETT and G. K. TEAL attended a meeting of the Washington section of the Institute of Radio Engineers held in Washington.

C. J. DAVISSON spoke on *Electron Optics* at Brown University, Providence, and also addressed a group at the Taylor Instrument Company, Rochester.



Testing open-wire circuits at Phoenixville. Left to right—
C. H. Gorman, M. T. Dow and L. F. Staehler

G. G. MULLER was in Washington in connection with telephone instruments for the U. S. Navy.

K. K. DARROW presented a series of lectures on *Electricity, Atoms and Light* at the Lowell Institute, Boston.

V. L. RONCI visited Station WOR at Carteret, New Jersey, to test a 232B vacuum tube. He also visited the Driver-Harris Company in Newark in connection with the testing of the mechanical properties of wire used in vacuum tubes.

H. E. IVES and H. B. BRIGGS presented a paper *The Optical Constants and Photoelectric Emission of Potassium* at a meeting of the National Academy of Sciences held at the University of Virginia, Charlottesville, Virginia.

E. F. KINGSBURY attended the Television and Facsimile Committee meeting of the Radio Manufacturers Association at Rochester, during the recent convention of the Institute of Radio Engineers.

E. J. KANE was at Hawthorne in connection with the manufacturing program for crossbar switching equipment.

J. G. FERGUSON was at Hartford with engineers from the Installation Department of the Western Electric Company to inspect the installation of an improved dial toll selector frame.

* * * * *

J. M. FINCH who completed twenty-five years of service in the Bell System on November 28, joined the Installation Department of the Western Electric in 1910. He became a trouble shooter in the initial installation of the Schuyler manual office, then went on similar work to Asbury Park. Returning to New York, he became a supervisor on the conversion at the old Lenox exchange where the "A" board was changed from the one-light to the three-light system.

Late in 1911 Mr. Finch transferred to the Engineering Department of the Western Electric Company at West Street entering the chemical group on insulating material research. His interests at that time included development work on cable and condenser papers. In this connection he wrote one of the first speci-

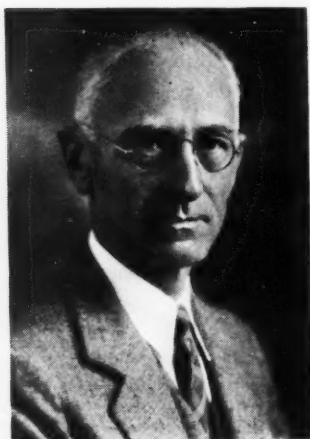
fications covering cable paper and later became intimately connected with development work leading up to specifications covering condenser papers, phenol fibre and other insulating materials. In the early work on cable paper the Laboratories found that low paper acidity was necessary to prevent embrittlement during the severe cable-drying operation. The Laboratories were among the first to realize the importance of acidity control and the group with which Mr. Finch was connected developed the original acidity test method which was used during the period from about 1912 to about 1925.

He was also actively connected with the early development of methods for testing the original Western Electric black enamel wire insulation and then with the investigation of varnish type enamels which, due to their superiority, were later adopted by the Western Electric Company. Mr. Finch is now connected with the development of condenser papers, condenser paper specification requirements and their test methods and has made important contributions in this field. In addition he is doing development work on special fabrics.

* * * * *

TWENTY-FIVE YEARS of service in the Western Electric Company and the Laboratories were completed by Philip Curran on the second of November. He

entered the Western Electric in 1910 as a general assistant in the power plant which then supplied all of the electric service to the building. He studied power plant and refrigeration engineering and in 1923 obtained a license which enabled him to become watch engineer. When the Sound Picture Laboratory was opened he was placed in charge of the refrigerating and air conditioning system in the building, remaining there for about two years. At present he is in charge of the power plant and



J. M. Finch



Philip Curran

associated apparatus in the
70 Bethune Street Building.

* * * * *

ON THE FIRST of December W. A. Bollinger completed twenty-five years of service in the Western Electric Company and the Laboratories. He joined the Engineering Department of the Western Electric Company at Hawthorne in 1910 as a draftsman. Three and a half years later he came to West Street in the equipment division of the Engineering Department and engaged in equipment engineering for the initial semi-mechanical installation at Newark, New Jersey. From September, 1917, to May, 1919, he served in the World War with the Research and Inspection Division of the Signal Corps. On his return to the company, he was placed in charge of the equipment drafting group and later, of the cable drafting group. Since 1925 he has been in charge of an important service division of the Systems Development Department.

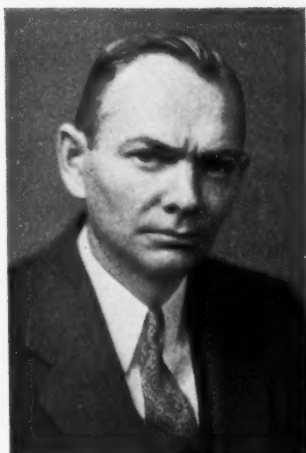
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P. L. WRIGHT, who completed a quarter century of service in the Bell System on the twelfth of December, joined the Southwestern Bell Telephone Company where he spent nine years in the Plant Department. He transferred to the Engineering Department of the Western Electric at West Street in 1919 as a development engineer, first on PBX circuit design and then on manual switchboard design. In 1925 he became a supervisor in charge of relay winding design and in 1927 a supervisor in the manual circuit design group. Since 1928 he has been in charge of certain special engineering required on customers' orders for local systems equipment received by the Western Electric Company.

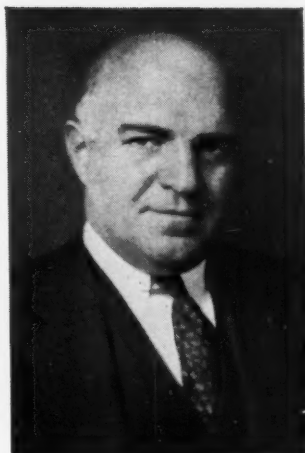
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F. F. SIEBERT and F. T. FORSTER were in Philadelphia to discuss storage battery

January 1936



P. L. Wright



W. A. Bollinger

problems with engineers of the Electric Storage Battery Company. L. A. Leatherman, accompanied by P. Woolcott of the A. T. and T. Company, also visited this company to discuss battery maintenance problems.

H. T. LANGABEER visited several PBX power plants in Cleveland.

T. D. ROBB spent several days in New Haven on tests of some recently designed accurate testing dials.

O. D. ENGSTROM recently sailed on the *S. S. Manhattan* for London, England, where he will coöperate in the installation and testing of new privacy equipment for the transatlantic telephone system. His office, while in London, will be with L. F. Morehouse, Technical Representative, at Bush House.

A. A. HEBERLEIN was in Philadelphia on matters relating to the operation of vacuum tubes in 1000-cycle ringers.

R. L. KAYLOR and F. H. WILLIS were at Provincetown, where they made noise tests and devised means for reducing noise on the ultra-short-wave radio telephone circuit between Provincetown and Green Harbor, Massachusetts.

J. H. SHUHART, who is stationed at Phoenixville, came to New York for several days to discuss apparatus used for high-frequency measurements on open-wire lines.

HAROLD B. NOYES spent three weeks in the vicinity of Cleveland studying at-

tenuation, noise, and cross-talk conditions in the buried rubber-covered wire recently installed in the rural plant of the Ohio Bell Telephone Company.

* * * * *

MEMBERS OF THE Laboratories learned with regret of the sudden death of James Hardiman on December 7. Mr. Hardiman came to the Laboratories in November,



James Hardiman

1929, as a general assistant in the Power Plant. For the past few years he has been doing maintenance work throughout the building. Recently he was elected Employees' Representative for the Power Service group and in this capacity served in two of the regular meetings.

* * * * *

TESTS ON low-frequency inductive interference with grounded telegraph circuits in cable were conducted in Philadelphia by L. C. Roberts, K. L. Maurer and W. W. Sturdy with R. H. Card and M. L. Lehman of the A. T. and T. Long Lines Department.

C. C. CASH has returned from Denver, where he was conducting tests on methods for reducing lightning interference to carrier telegraph circuits.

G. B. THOMAS attended the fall meeting of the Middle Atlantic Section of the Society for the Promotion of Engineering Education, which was held at the University of Pennsylvania, November 2.

JOHN MILLS spoke before the Worcester Engineering Society, on *What Electricity Is Doing for Music*.

M. B. LONG and JOHN MILLS spent several days in the West making arrangements for the proposed Bell System Exhibit at the Texas Centennial Exposition next summer.

PAUL B. FINDLEY described to the Brooklyn Engineers Club some of the life-tests applied in the Laboratories.

THE LABORATORIES were represented in interference proceedings at the Patent Office in Washington by W. C. Kiesel and G. F. Heuerman before the Primary Examiner and J. M. Holahan before the Board of Appeals.

H. A. FLAMMER recently made a trip to Harrisburg, Lancaster, York and Philadelphia, Pennsylvania, and Trenton, New Jersey, in connection with outside plant apparatus.

FOUR STAR SERVICE emblems were awarded to the following members of the Laboratories during the past month: Anton Loder and F. C. Kahnt of the Research Department on the nineteenth and twenty-fourth, respectively, J. E. Rogers of the Systems Development Department on the fifteenth and M. A. Weaver of the Transmission Development Department on the twentieth.



A Radio Receiver for the Private Plane

By J. E. CORBIN
Radio Development

THE radio needs of the private plane differ from those of transport and mail planes. In the first place space is generally more limited and weight must be more carefully considered, but besides these physical restrictions the interests and motives of the pilot are different. Commercial pilots fly the same routes day after day, and their chief objective is to reach their terminals safely and on time. The private flyer, on the other hand, generally has a more lenient schedule. While he may fly established air lanes to a large extent, there is usually more freedom to his movements and more of the element of pleasure in his objectives. With a view to meeting these somewhat special needs of the private flyer, the Laboratories have developed a new radio receiver which will receive not only the beacon and weather bands, but the broadcast band as well.

This new receiver, known as the 17A, measures barely $7\frac{3}{4}$ inches each way and weighs but eleven pounds. It employs only three tubes and may be operated with batteries alone, although in normal use a dynamotor, run from a 12-volt storage battery, will generally be employed to supply 200 volts for the plates. The outside appearance of the receiver is shown in the photograph at the head of this article. There are three controls on the front. The one in the center is for tuning, and the illuminated dial immediately above it has two scales, one for the beacon and weather band from 200 to 400 kc. and the other for the broadcast band from 550 to 1500 kc. The knob at the lower left is a transfer switch to change from one band to the other, and that at the lower right is the volume control. Power connections are made through the multi-contact jack and plug just

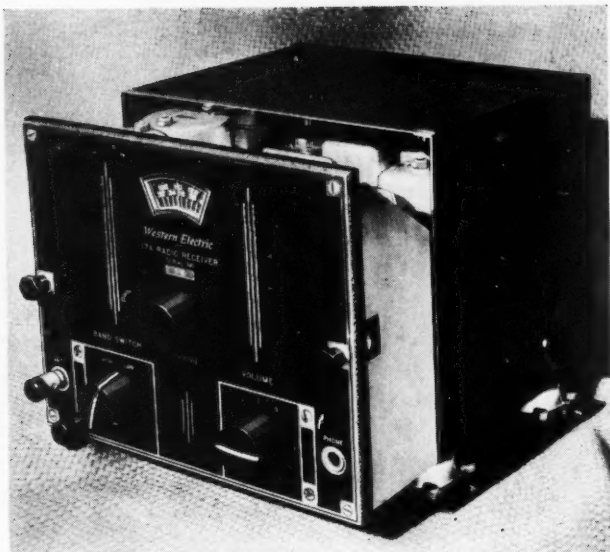


Fig. 1—The 17A radio receiver, showing the metal chassis, the front panel, and the shockproof mounting which protects the apparatus from injury

visible at the rear of the right side.

All apparatus is mounted on a metal chassis, which carries the front panel and is arranged to slide into the outer case as shown in Figure 1. To withdraw the chassis it is necessary only to turn the two small knobs, one on each side of the front. The case, in turn, rests on a shockproof base. It is designed to be mounted close to the pilot where he can manipulate the controls directly. The compact arrangement of the apparatus is indicated in Figure 2 which shows the chassis removed from the case.

The small size of the set is no measure of its performance. The long experience of the Laboratories in designing radio apparatus for all types of service has made it possible to obtain the required selectivity and sensitivity combined with liberal power output and good

quality of signal in a very small set. A special feature is the varistor, which serves to reduce the intensity of static crashes exceeding a certain value. This element, completely contained in a cylinder only three quarters of an inch in diameter and a quarter of an inch high, is shunted across the output of the final amplifier through a condenser. At normal operating voltages it has a very high impedance and thus little effect on the output voltage. For voltages above the normal range, however, its resistance drops sharply and essentially short-circuits the output. Its action is instantaneous, and the low-

ered resistance lasts only for the duration of the high voltage disturbance, which may be only a few milli-seconds. The short-circuiting of the output for

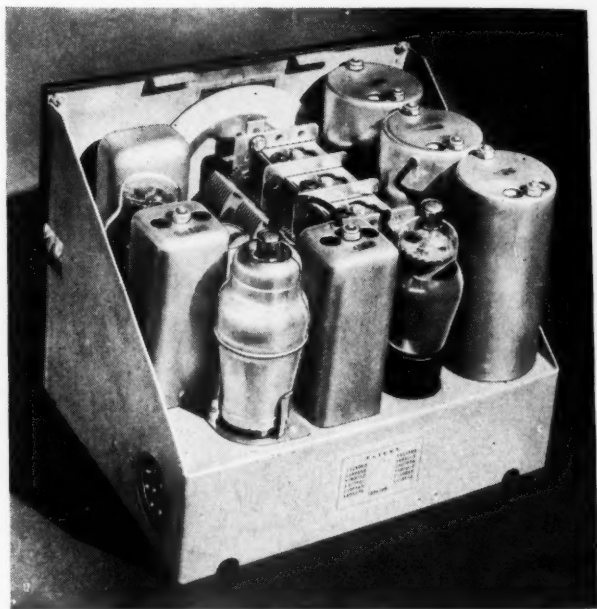


Fig. 2—All wiring and minor circuit elements are mounted on the underside of the chassis—the upper surface carrying only the tubes, condensers, and coils

these very brief periods has little effect on the intelligibility of the signals being received except under very severe conditions.

The receiver employs a super-heterodyne circuit as indicated by the simplified schematic of Figure 3. There is first a band-pass preselector, then a converter stage, with one tube combining the function of oscillator and first detector; then an intermediate stage which in one tube unites an intermediate-frequency amplifier, a second detector, and a reflexed stage of audio-frequency amplification; and finally a power output stage which utilizes the third tube and the varistor. The circuit to the right of the preselector remains the same for both beacon and broadcast bands. The action of the transfer switch changes the coils in the preselector and oscillator. The preselector circuit is an important factor in increasing the selectivity of the receiver and in giving a high signal step-up from antenna to grid of the first tube.

The overall "close up" selectivity of the receiver is shown in Figure 4. The selective action of the preselector has been made to provide adequate suppression of image frequencies and to reduce interfering signals of this character to so low a value that cross-

talk in the tubes is negligible. The width of the voice band is about 2000 cycles. In the interest of high selectivity for beacon signals spaced only 6 kc. apart, the voice band must be kept moderately narrow, but it has

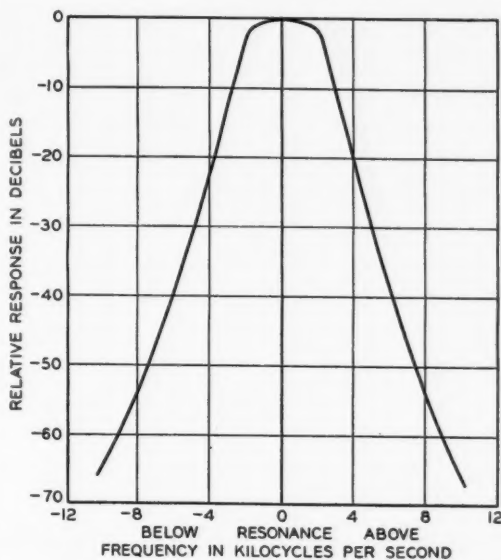


Fig. 4—Overall selectivity of the beacon and weather band of the 17A receiver

been made wide enough to give good intelligibility. The sensitivity, shown in Figure 5, is very uniform over the bands and is higher than is obtained with many four and five tube sets. Signal strengths as low as 15 microvolts per meter may be readily picked

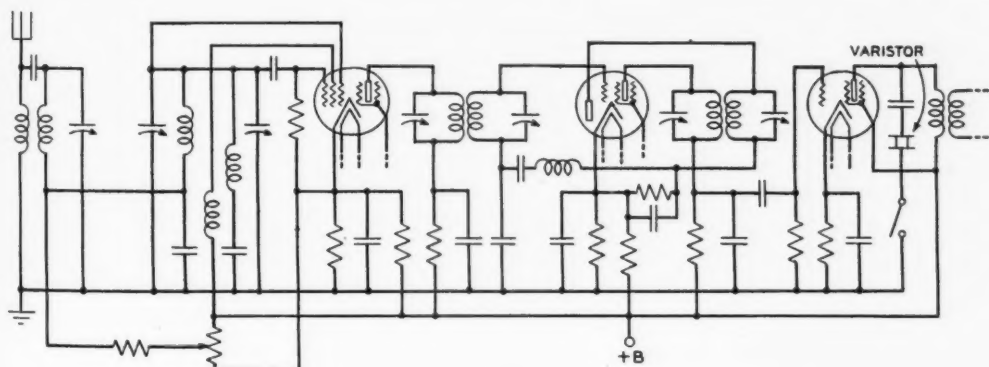


Fig. 3—Simplified schematic of the 17A radio receiver

up with this radio receiver using an antenna of the usual aircraft type.

Although this receiver was developed primarily for the private flyer, it also serves admirably as an emergency receiver for commercial planes, because it may be completely battery operated with small current drain. The filaments are normally arranged for connection to a twelve-volt battery, but a series resistance is in the circuit, and if the battery connection is made inside the resistance, full

heater current may be obtained from a six-volt supply. A ninety-volt B battery may be used under these conditions for plate voltage. While the set is designed for a normal supply of two hundred volts, operation on the lower voltage does not seriously impair the sensitivity or power output. The peak output at full voltage is one watt, and since sixty milliwatts is adequate for headset reception there is an ample reserve of power for these emergency conditions.

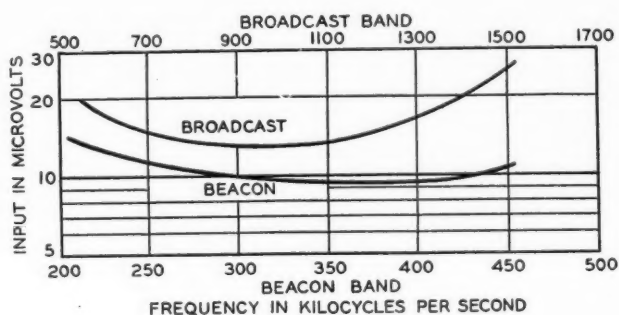
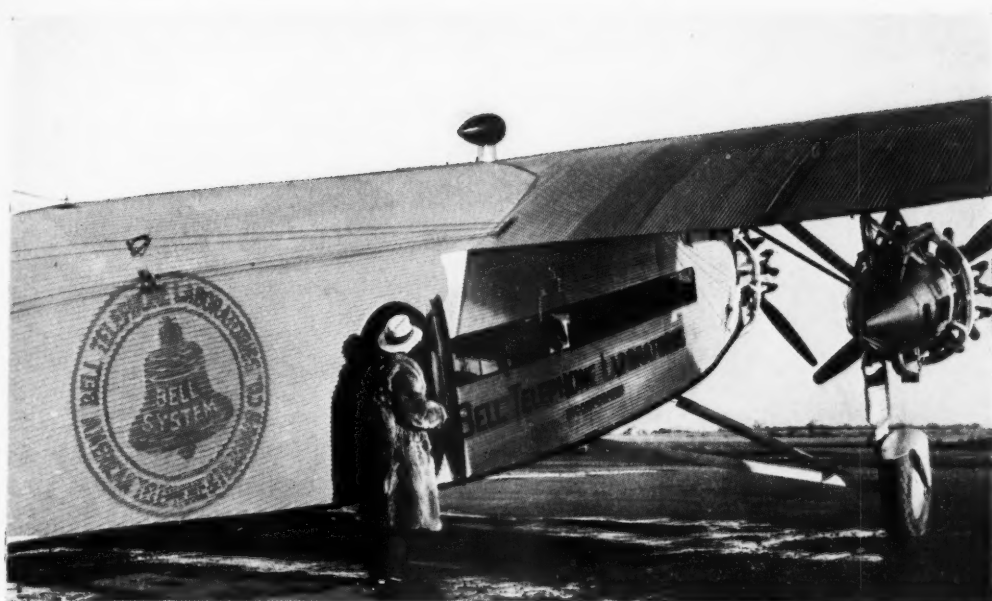


Fig. 5—Sensitivity curves of both beacon and broadcast bands of the 17A radio receiver



A Radio Compass for Aircraft

By C. B. AIKEN
Radio Development

VESSELS at sea have long used radio compasses to determine the direction of shore stations or of other vessels. Careful operation is required to secure accurate bearings, however, and the apparatus itself is rather heavy and bulky, so that such compasses have been employed only to a very limited extent by aircraft. Recently, however, Bell Laboratories made available an easily operated radio compass for use primarily with Western Electric marine radio telephone equipment.* Recognizing the possibilities of wider usefulness for this very effective visual-indicator instrument, they have incorporated some of the basic principles in a smaller and lighter weight set for use as a radio compass for aircraft. It consists of a loop assembly and a compass control unit,

and is designed for use in conjunction with the 17A radio receiver.*

This receiver is a sensitive three-tube set housed in a small metal cabinet measuring about eight inches each way. It can receive either the broadcast band, from 550 to 1500 kc., or the beacon and weather band, from 200 to 400 kc., and thus when used with the compass equipment may serve the double duty of giving entertainment and assisting in the navigation of the ship. A small switch on the front of the cabinet makes the change from one band to the other.

This new radio compass includes two loops, a compass control unit, similar in size to the 17A receiver, an output filter unit, and an indicating meter for installation on the instrument panel. The control unit has three tuning ranges, which with the two

*RECORD, June, 1935, p. 300.

*RECORD, p. 161 of this issue.

loops permit the pilot to obtain bearings on any of the beacon or airway weather stations as well as on any broadcast stations. He may use the apparatus to determine the direction of appropriate station, and thus ascertain his own position by cross bearings, or he may use it as a "homing" device to fly directly toward a station. The circuit arrangement permits him to listen to a broadcast program at the same time he is determining a bearing on the station from which the signal is being received.

The loop system, which is mounted in a streamlined housing to reduce wind resistance, is designed for mounting either above or below the fuselage, and is connected to the compass control unit through a shielded cable. A hand wheel inside the cabin is employed to turn the loop, and a dial indicates the angle the loop makes with the axis of the plane. As with other radio compasses, the principle involved is that a loop antenna gives maximum output when the radio waves are traveling in the plane of the loop, and minimum when they are perpendicular to the loop.

A loop by itself determines only the line of direction. Thus it might, for example, indicate that the waves were traveling in a north and south line, but would not determine whether they were coming from the north or south. To determine the "sense" of the direction, as it is called, a non-directional antenna is required in addition to the loop. For this purpose the regular antenna of the plane may be used, or a short simple antenna may be substituted.

Extensive training is not required for the operation of the compass. A two-position key, furnished as part of the equipment and mounted over the antenna binding post of the 17A re-

ceiver, is used to connect the receiver either to the non-directional antenna or to the compass control unit. In taking a bearing, this key is first thrown to the antenna position and the station on which a bearing is to be taken is tuned in on the receiver as usual. The key is then thrown to the compass position, and the tuning knob on the compass control unit turned until a maximum signal is heard. The position of the meter pointer then indicates whether the loop is at right angles to the direction of the station, or, if not, indicates the direction in which the hand wheel should be turned. A low-frequency potential, used to operate the indicating meter, is superimposed on the signal from the loop antenna by the compass circuit, and gives a low-pitched tone signal which is heard at all times except when the loop is at right angles to the direction of arrival of the radio waves. This tone serves as an auxiliary indication of the position of the loop relative to the direction of the incoming radio waves.

To obtain a bearing, the hand wheel of the loop is turned in the direction from the needle toward mid-scale until the pointer of the meter comes to zero. The superimposed tone disappears at the same time, and the angle of the radio station with respect to the axis of the ship can be read directly from the dial above the hand wheel. As long as the loop is properly oriented with respect to the radio station the program will be heard without any superimposed tone, but as soon as the loop is off the bearing, the tone will come in. When the compass is used as a homing device, the dial on the hand wheel is set at zero and the plane turned until the meter pointer comes to zero and the tone disappears, when the plane will be fly-

ing directly toward the radio station. As soon as the plane deviates from this direction the meter will be deflected and the tone will be heard. If when turning the hand wheel the pointer moves in the opposite direction, the hand wheel is turned further in the same direction. This will cause the pointer first to move still farther from zero and then finally return to zero, when the true bearing may be read from the scale. Because of the visual indicator, continuous monitoring with head phones is not necessary to the operation of the compass.

One of the major advantages of this type of compass is the visual indication made possible by the use of a non-directional antenna and a loop pick-up in combination. During rainstorms, however, the straight antenna may introduce considerably more static than is effective in the loop alone. To make it possible to eliminate this, there is a two-position switch on the compass control unit, which permits two methods of determining a bearing. In one position of the switch, the operation is a visual function as just described. With the switch in the other position, the non-directional antenna is not employed and the superimposed potential for the operation of the meter is also omitted. With this latter method, the direction of the radio station is indicated aurally only by the disappearance of the signal when the loop is at right angles to it. When the compass is being used as a "homing" device under these conditions the loop may be turned away from the "null" for short intervals to hear weather announcements or broadcast programs. The only advantage of this alternative method, which does not employ the non-directional antenna, is that in the presence of certain types of static, re-



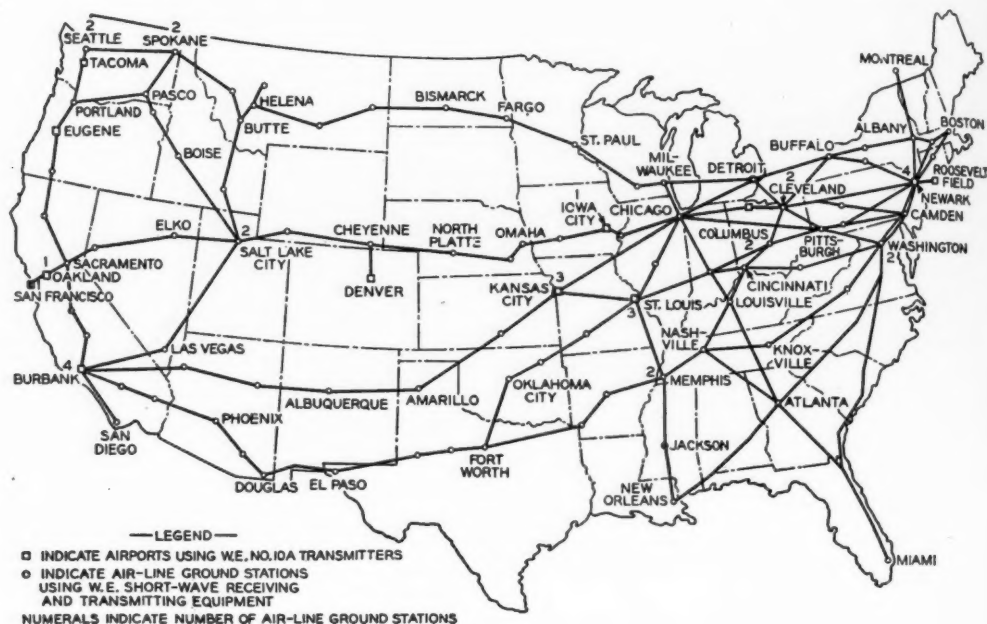
Fig. 1—Capt. A. R. Brooks demonstrates the use of the new radio compass in the Laboratories' Fairchild plane

ception on the loop alone is sometimes quieter, and the course may be flown and messages received with less interference than might be effective on the visual indicator option. For the most part, however, the very definite advantages of the right and left visual indicator (as compared with the "null" signal in headphones) and of the continuous "sense" indication (as compared with the 180 degree ambiguity of the loop collector by itself) are expected to be of such importance that the alternative method will be resorted to only infrequently.

Several models of this radio compass have been built and are being

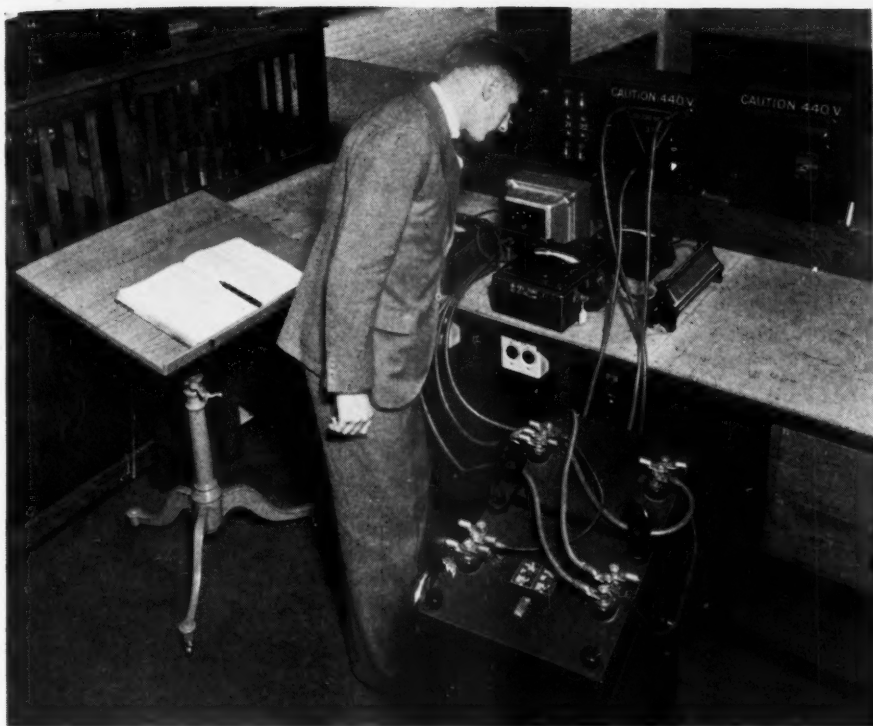
tried out experimentally. Such an installation in the Laboratories' Fairchild plane is shown in Figure 1. Here the compass unit is at the left and the 17A receiver—similar to it in size and appearance—is at the right. Below is

the power supply unit, and above is the control wheel of the loop. In the photograph at the head of this article the loop antenna in its streamlined housing can be seen installed on the Laboratories' Ford plane.



The rapid extension of commercial air lines in recent years is to a very large extent a tribute to the skill, ingenuity, and far-sightedness of American airplane designers. Even the finest type of modern plane, however, would not alone provide adequate safety in long flights. Ready and reliable communication between plane and ground is essential; and this need is being met by the rapidly increasing use of radio communication. In this field the Western Electric Company has taken a leading part.

The widespread use of radio apparatus designed by the Laboratories is partially indicated by the map which shows the location of airport and air-line ground stations that employ Western Electric equipment. It does not indicate, however, the extensive use of Western Electric apparatus in the planes themselves, where radio serves for two-way communication with the ground, and for the reception of weather reports and beacon signals.



Transformer Testing Laboratory

By R. W. DeMONTE

Transmission Apparatus Development

TRANSFORMERS and retardation coils have been used in telephone circuits for several decades, and extensive investigations have been made in the Laboratories of their design and performance at voice and carrier frequencies. There were few uses for power transformers in apparatus developed by the Laboratories, however, until the introduction of the electronic rectifier and the heater-type vacuum tube enabled communication apparatus to draw its energy directly from alternating-current mains. With this change in the method of supplying power the situation has rapidly altered; small power transformers are now required in large numbers for these and other purposes,

as well as retardation coils for the filters which suppress the ripple in the output of the rectifiers.

The development of these transformers and retardation coils requires laboratory facilities for verifying design, for determining behavior under load conditions, and for a variety of miscellaneous tests. To provide more adequately for these needs, floor space was recently made available in the West Street building. Part of it is utilized for power-supply apparatus and for a work bench for making miscellaneous mechanical adjustments, but the major part of the space is divided into eight laboratory compartments as indicated in perspective plan shown in Figure 2. They vary in



Fig. 1—The transformer with its control panel, at the right of the main switchboard, is enclosed as a matter of safety

size from 38 to 110 square feet, and to some extent these areas are arranged with certain specific tests in view.

The six compartments in the north

end of the room are shown in Figure 3, and the other two are similar in general arrangement and equipment. Each is surrounded with a five-foot fence with a gate in the corridor side, and each has a laboratory bench covered with transite to reduce the fire hazard, and a writing stand for the engineer's notebook. The floors are covered with rubber matting, and as an additional precaution safety buttons are installed in each compartment by which the entire power supply of the laboratory may be immediately interrupted. Power panels and outlet boxes are also provided in each compartment to make the various types of power supplies readily available to the engineers.

The main switchboard for the transformer laboratory is shown in Figure 1, and in Figure 4 is given a simplified schematic diagram indicating the various types of power available and how they are secured. The main source of supply is a three-phase, 220-volt, 60-cycle circuit feeding through the main circuit breaker, which may be tripped by the safety switches in

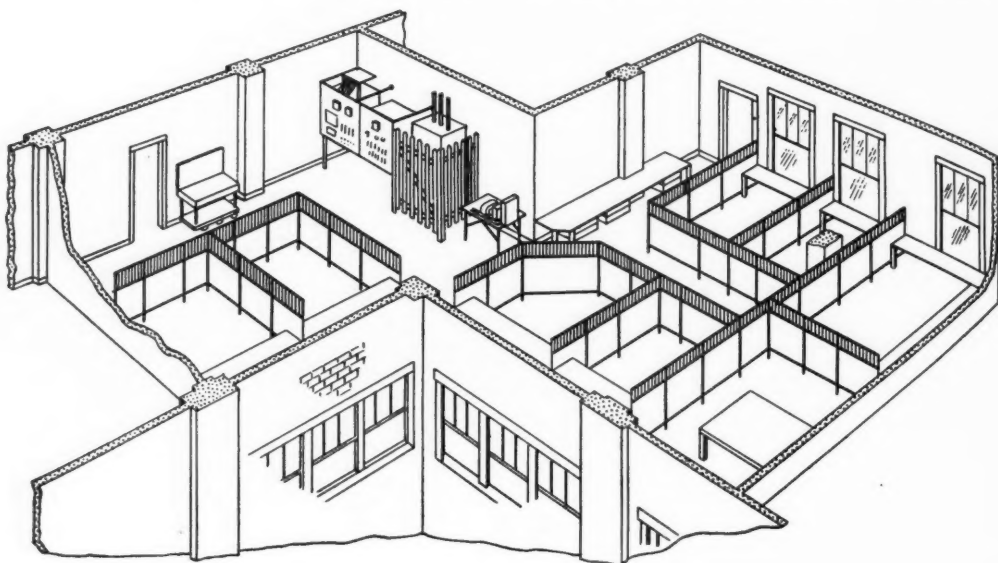


Fig. 2—Perspective plan of the power-transformer laboratory



Fig. 3—The compartments are similar in having a bench, writing stand, and outlet boxes for power supply, but vary in size and in their special equipment

the individual compartments. Two circuits are connected to the laboratory side of this circuit breaker: one running to the primary of a three-phase transformer having secondary voltages of 110, 220 and 440 volts, and the other to a three-phase motor that drives a 125-volt d-c generator. One connection from this generator provides the 125-volt d-c supply to the laboratory, and another supplies an adjustable-speed motor directly connected to three 300-volt single-phase alternators. The motor is adjustable over a two-to-one speed range, and over this range the frequency of the three generators varies from 25 to 50, 50 to 100 and 100 to 200 cycles respectively. Besides these main supplies, there is a small motor-generator furnishing

eight hundred cycles at one hundred volts, and a 150-volt battery.

The transformer control panel is shown in Figure 5. Besides the main switch and various fuses, it carries switches for changing the taps to obtain any of the three available voltages. Connections from the secondary of this transformer run to main

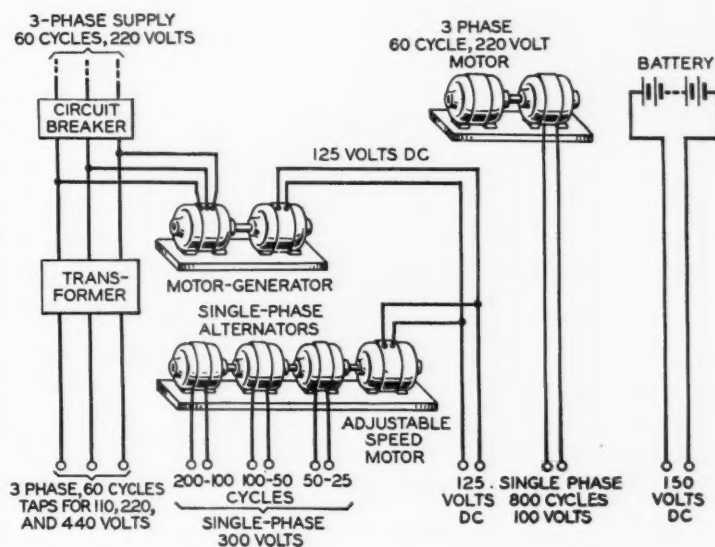


Fig. 4—Simplified schematic diagram of power supply

switches and three-phase outlet boxes in four of the compartments. The two switch-board panels at the left of the transformer enclosure, Figure 1, control the two main motor-generator sets, and provide patching jacks whereby any of the various supplies can be connected to any of the laboratory compartments. Two two-wire circuit jacks are located in each compartment and are given the same circuit numbers as the corresponding jacks at the main

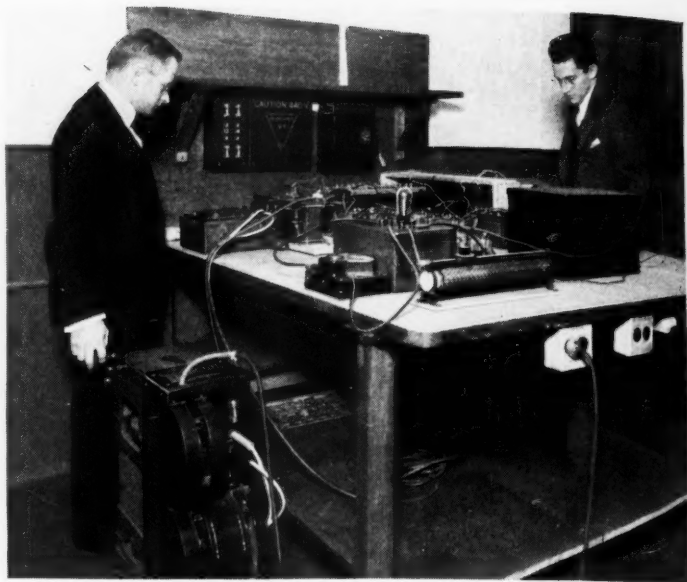


Fig. 6—C. A. Brigham and B. E. Stevens making peak voltage measurements on a rectifier circuit



Fig. 5—The transformer panel carries switches for selecting 110, 220, or 440 volts as well as the main switch shown being operated by L. E. Milarta

board. The various power supplies at the main board also appear in jacks so that they can be connected to any of the laboratory circuits by means of patching cords.

In the various tests carried on there is frequently needed a wider voltage range than is available from the main supply sources. This is secured by portable apparatus in the compartments. In Figure 6, for example, is a test set-up using a single-phase induction regulator, which gives a smooth control of voltage over a wide range. A three-phase induction regulator is also available, and is shown in use in the photograph at the head of this article. Besides this method of obtaining different voltages, various forms of commercial transformers, arranged to give voltage variation by taps in one form or another, are employed.

Power transformers and retardation coils are frequently required to operate at voltages where the insulation of the windings and the formation of corona become important.



Fig. 7—E. E. Aldrich testing a grid-controlled rectifier with a three-element oscillograph (at the extreme right)

One of the compartments is provided with special facilities for corona studies, with a circuit that provides voltages up to 15,000 volts. This circuit may also be employed for making dielectric strength tests on coils and insulating materials. With power transformers, however, the failure of insulation may occur between turns, and dielectric strength tests between winding and ground are of little value in determining weakness of this type. An induced voltage test circuit is provided in one of the compartments for this type of test, as shown in Figure 8. Voltages at 180 cycles and up to 2500 volts are made available by this circuit. The effects of current and voltage wave shape may also be of considerable importance, and a three-element oscillograph, shown at the extreme right in Figure 7, is available for studies of this nature.

Retardation coils for ripple suppression are required to operate both with an a-c potential across their winding, and with a direct current passing through the coil. The inductance of the coil depends on both, and

to aid in the design of such coils a superimposed inductance bridge* has been provided, which will measure inductance with as much as 2200 volts a-c across the winding and 12 amperes d-c flowing through it.

The behavior of coils and transformers at elevated temperatures is frequently a matter of considerable importance, and an electric oven has therefore been provided in which temperatures are available

up to 265 degrees Fahrenheit. The oven is equipped with thermostatic control, which allows the temperature

*RECORD, December, 1935, p. 131.



Fig. 8—J. P. Whistler operating the induced voltage testing set

to be held constant at any temperature within its operating range. This oven is also used for special studies of insulating and potting compounds.

With the laboratory facilities available, transformers and retardation coils at all usual ratings may be satisfactorily developed and tested. Usual procedure, after a coil or transformer has been developed, is to have a model built in the Model Shop. Complete tests simulating the actual cir-

cuit conditions are made on the model to verify the design. Tool-made samples are also tested in the transformer laboratory as a further check on the operating characteristics of each design. Due to the continuously increasing demand for small coils in all types of apparatus, laboratory studies are always in progress seeking means of improving the quality and increasing the life of transformers and coils, as well as of reducing their cost.

A Pattern of Cycles and Bels

"A special blue ribbon goes to John Mills' 'A Fugue in Cycles and Bels,' a most unusual book on music. For here a radio and telephonic engineer, whose witty and lucid pen has already pleased us with 'Letters of a Radio Engineer to His Son' and 'Signals and Speech in Electrical Communication,' tells us the rôle which electricity plays in music today, and is bound increasingly to play tomorrow. He weaves cycles (units of vibration frequency which determine pitch) and bels (units of acoustical power or loudness) into a pattern which explains the whole electrical study of sound. Technical, but deeply fascinating.

"Just consider this example of the range and sensitivity of the listening ear—that if a person speaks normally into your ear at a distance of half an inch, you receive 10,000,000,000 times more acoustical power than the ear needs to detect a sound. There's a moral there somewhere."

—Theodore Hall, "No End of Books," Washington Post.

Contributors to This Issue

UPON receiving the B.A. degree from the University of Oregon in 1927, E. A. Veazie joined the Technical Staff of the Laboratories. Here, with the Vacuum Tube Development group, he has been engaged principally in the design of multi-grid tubes for both low and high frequency uses.

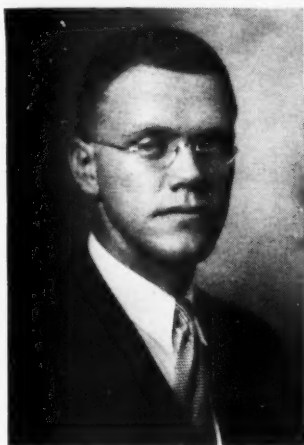
C. B. AIKEN received a B.S. degree from Tulane University in 1923. He then went to Harvard and received an M.S. in Electrical Communication Engineering in 1924 and an M.A. in Physics the following year. After two years with Mason, Slichter and Hay of Madison, Wisconsin, engaged in geophysical exploration, he joined the Laboratories in 1928. Here he was occupied with work on aircraft radio receivers and special measuring equipment. In 1930 he was made supervisor in charge of

broadcast radio receiver development—a position he held at the time the radio compass was developed.

A. D. KNOWLTON received the B.S. degree from Haverford College in 1920, and in the fall joined the Technical Staff of the Laboratories. He was first associated with the Equipment group where he did engineering work for the first dial instal-

lations in New York City. Later he transferred to the Manual Switchboard group and was engaged in the design of call indicator equipment and other manual switchboard developments. In 1931 he transferred to the telegraph group where he worked largely on teletypewriter switchboards. He is now supervisor of the group developing telegraph and teletypewriter equipment.

GEORGE B. ENGELHARDT graduated from Cornell Uni-



C. B. Aiken



E. A. Veazie



A. D. Knowlton



G. B. Engelhardt



R. W. DeMonte



J. E. Corbin



E. P. Felch

versity in 1930 with the E.E. degree. Shortly after he joined the Technical Staff of the Laboratories, associating himself with the Carrier Transmission Research group. Here he has been concerned chiefly in developing measuring apparatus for use at very high frequencies, such as are proposed for transmission over coaxial structures. Measurement of phase shift at these frequencies has been one of his major studies.

R. W. DEMONTE joined the Transmission Apparatus group of the Laboratories in 1920. During the next five years he took the course for Technical Assistants at the Laboratories, and also studied at Cooper Union, receiving the B.S. degree in Mechanical Engineering in 1925. During this period and for the next year he was engaged chiefly in the design of filters and networks. In 1926, and for the following three years, he turned to the design of audio-frequency coils. Since 1929 he has been in charge of the design of transformers and coils used in regulators and rectifiers.

J. E. CORBIN received the degree of B.S. in Electrical Engineering from Penn-

sylvania State College in 1930 and immediately joined the technical staff of the Laboratories. Here as a member of the radio development group he has engaged in the design of radio-frequency distribution systems, and of radio receivers for broadcasting stations and aircraft.

E. P. FELCH graduated from Dartmouth College in 1929 with the A.B. degree in Physics, and at once joined the Technical Staff of the Laboratories. Following a brief training period with the Western Electric Installation Department he entered the Trial Installation group in the Systems Development Department. Transferring in 1930 to the Electrical Measurements group of the Apparatus Development Department, he has since been engaged in the development of carrier and radio-frequency oscillators, detectors, and phase-measuring equipment. In connection with the telephotograph project during 1934, he was active in the design of delay measuring apparatus and spent some time in the field giving instructions in the technique of delay measurement.